METHODS AND APPARATUS FOR ADAPTING A HOP SEQUENCE WHEN ESTABLISHING A COMMUNICATION CONNECTION

FIELD OF THE INVENTION

[0001] The present invention relates to communication systems in which transmitters and receivers hop frequencies while communicating. More particularly, the present invention relates to adapting hop sequences in a frequency hopping communication system.

BACKGROUND

[0002] In the last decades, progress in radio and VLSI technology has fostered widespread use of wireless communication in consumer applications. Both the quantity and variety of types of wireless communication devices has been fostered by the availability of unlicensed communication bands, such as the ISM (Industrial, Scientific and Medical) radio band at 2.45 GHz, which may be available almost globally. The ISM band provides 83.5 MHz of radio spectrum.

[0003] The widespread use of wireless communication devices, especially concentrated in the ISM band, may sometimes lead to interfering radio signals between groups of communicating devices or with other radio transmission devices. One way to reduce the affect of interfering radio signals is to spread communication signals across a radio band. The FCC in the United States currently requires radio equipment operating in the 2.45 GHz band to apply some form of signal spreading when the transmit power exceeds about 0 dBm. Known forms of signal spreading include symbol level spreading, such as applying direct-sequence (DS) spread spectrum, and channel level spreading, such as frequency hopping (FH) spread spectrum.

[0004] In frequency hopping systems, spreading is provided by transmitting the information data stream over radio frequencies that vary in a predetermined manner for each transmission. One such industry standard system is known as Bluetooth, which was introduced to provide device connectivity, especially among portable devices, like mobile phones, laptops, personal digital assistants (PDAs), and other mobile devices. The Bluetooth devices use frequency hopping and may support both data and voice communications. More particularly, Bluetooth devices that support voice transmissions may use both frequency hopping and robust voice coding. One example of such frequency hopping includes a nominal hopping rate of 800 hops/second through the 2.45 GHz ISM radio band.

[0005] Devices based on the Bluetooth system concept can create so called piconets, which comprise a master device and one or more slave devices that communicate via FH piconet channels. Devices communicating on a FH piconet may hop between channels according to a hop sequence that may be defined by the address or identity of the device acting as the master. While communicating, devices may remain synchronized by hopping among the same channel sequence and at the same phase, or location, within the sequence.

[0006] The phase of the communicating devices may be synchronized with a shared clock reference. Bluetooth devices may each have their own free-running system clock which may be synchronized when a communication link is established. For example, a slave device may add a time offset to its clock such that it becomes aligned with the clock of the master device. By using the master address to select the proper hopping sequence and by using the time offset to align to the master clock, the slave device may keep in hop synchrony to the master device. Such communication is further described in commonly owned U.S. patent application Ser, No. 08/932,911, filed Sep. 18, 1997 in the name of J. C. Haartsen and entitled "Frequency Hopping Piconets in an Uncoordinated Wireless Multi-User System," which is hereby incorporated herein by reference in its entirety. Further reference is made to the commonly owned U.S. Pat. No. 6,108,366 issued on Aug. 22, 2000, which is hereby incorporated herein by reference in its entirety. Further reference is made to commonly owned U.S. patent application Ser. No. 09/418,562, filed on Oct. 15, 1999 in the name of J. C. Haartsen and entitled "Method and apparatus for sequence adaptation," which is hereby incorporated herein by reference in its entirety.

[0007] Communication between two or more devices may be established by one device transmitting a paging message to another device. Upon receiving the paging message, the receiving device may transmit a response to the paging device so that the devices may form a synchronized FH communication link.

[0008] Establishing a FH communication link may be complicated or delayed when one of the communication devices to be paged is capable of switching between a scanning mode, in which it scans for a paging message, and a sleep mode, in which paging messages may not be received. Such receiving devices periodically awake from the sleep mode to scan for any paging messages from a paging device (i.e., master device). With many such communication devices, the paging devices may not know when and on what hop channel the paged device will listen for paging messages. Moreover, the presence of interference may prevent the paged device from receiving a paging message even when it is transmitted on the same hop channel on which the paged device is listening.

[0009] The operations for establishing a communication link between Bluetooth devices has been described in the commonly owned U.S. Pat. No. 5,940,431, issued on Aug. 17, 1999, and the commonly owned U.S. Pat. No. 6,389,057, issued on May 14, 2002, both of which are hereby incorporated herein by reference in their entirety.

SUMMARY OF THE INVENTION

[0010] According to embodiments of the present invention a method is provided for establishing a connection between a scanner device and a pager device over a sequence of hop channels. The scanner device is repetitively activated and a hop channel is selected from the sequence of hop channels as a function of a present phase. A determination is made as to whether the selected hop channel is a forbidden hop channel. A substitute hop channel is selected from the sequence of hop channels as the selected hop channel if the selected hop channel is a forbidden hop channel. The selected hop channel is monitored for receipt of a paging message during the present phase.

[0011] In other embodiments, interference on a selected channel may be monitored and a selected channel may be